STRATEGIES IN HUMAN LONG TERM MEMORY

Zimmer, A.
Lehrstuhl Psychologie III, Universität Regensburg
Regensburg, German Federal Republic

Introduction:

The aim of this study was threefold:

(1) detection of strategies used by the subjects in order to store and retrieve the items,

(2) comparison of the normative "is a" - hierarchy of concepts and superimposed concepts and of the empirical hierarchies as shown in free recall and in free card sorting,

(3) consideration of the consequences of the apparent organization in memory for the notion of the subjective lexicon.

The list of items which was given to 120 subjects (five groups with lists containing roughly the same items but differing in the way of organization) had the normative "is a" - hierarchy shown in figure 1; the items with asterisks were given in all conditions. The subjects had to recall the item list seven times; the first time immediately after the phase of memorizing and the last time six weeks thereafter.

Data analysis

The analysis of the free-recall-data (FRD) proceeded in two stages:

(1) transformation of the recall protocols into distance matrices.

(2) analysis of the distances by multidimensional scaling (a), hierarchical clustering (b), and semilattices (c).

(a) the multidimensional analysis was done by an adapted version of MINISSA (LINGOES/ROSKAM, 1971), which starts with a principal component analysis of the rank order distances and then maximizes the coefficient monotonicity.

(b) the hierarchical clustering was done by the transformation of the original distances in ultrametric distances by either the single linkage, the complete linkage, or the average linkage algorithm (SOKAL/SNEATH, 1963; JOHNSON, 1967).

The distances in hierarchical clustering fulfill the ultrametric triangle inequality

$$d_{ij} \leq \text{MIN}\,(d_{ik}; d_{jk}).$$

This inequality implies that the points i, j and k form a triangle with two equal sides inclucing and angle with less than 60°.

(c) in contrast to the standard procedure in free-card-sorting (MILLER, 1969) in our experiments the subjects were not constrained to construct disjoint categories. Consequently 21 subjects categorized superordinates in more than one category. This enabled us to analyze these data in the framework of the theory of semi-lattices (SZASZ, 1963).
A semi-lattice is defined asapartially ordered set with a least upper bound for any two elements and a maximal element for the whole set.
A tree structure is a semi-lattice with comparable upper bounds. A semantic interpretation of upper bounds are superordinates, which are comparable on behalf of their degree of abstraction. The maximal element is the most abstract superordinate.
It should be noted that approaches (b) and (c) are deterministic, therefore no stochastic optimization is possible.

Results

Neglecting the differences in the groups[x] because of identical trends there are to be found three types of gross strategies used by the subjects to retrieve the items. The frequencies of these types during the trials show ahomogeneous trend: the serial strategy decreases from 80,8 % to 8,33 % and likewise the mixed strategy: 14,17% to 0 % whereas the hierarchical strategy incerases from mere 5 % to 91,67%.

An further analysis of the protocols of the subjects using the hierarchical strategy shows that there are meny subtypes; the most important is the construction of subcategories in order to have the frequency in all classes (≈ 3). It can be shown (DIRLAM, 1972) that by this strategy the proportion: $\frac{\text{number of search steps}}{\text{number of addresses in the memory}}$ is minimized.

---

[x] The most striking differences is the time necessary for complete recall; the differences between the groups with hierarchically organized lists and the groups with lists in the form of associative chains were highly signification ($p\ (\alpha) < 0.00001$).

Another variant is the use of concrete items as paradigmata for classes. Subjects applying this variant start most often with the paradigma afterwards telling the class name and the other items of the class then they reproduce the higher order superordinates. After that they start again with the next paradigma.

The comparison of free-recall-hierarchies and free-cars-sorting hierarchies show that in the latter there are no indicants for paradigma. Therefore it seems reasonable to assume that paradigmata are a result of the recording during the trial or of the retrieval but not of the coding during the learning phase.

The serial order strategies too are not all alike on behalf of the underlying cognitive processes, whereas the processes in the beginning can be explained by simple local-temporal associations, the processes in the last trials are based on the so called episodic memory (TULVING, 1972).

The comparison between the free card data before and after the recall trials reveals some striking differences:

(1) whereas the "data before" can easily be represented in a two-dimensional configuration, "data after" show even in three dimensions a low coefficient of monotonicity (worse than for the "data before" in two dimensions[x]),

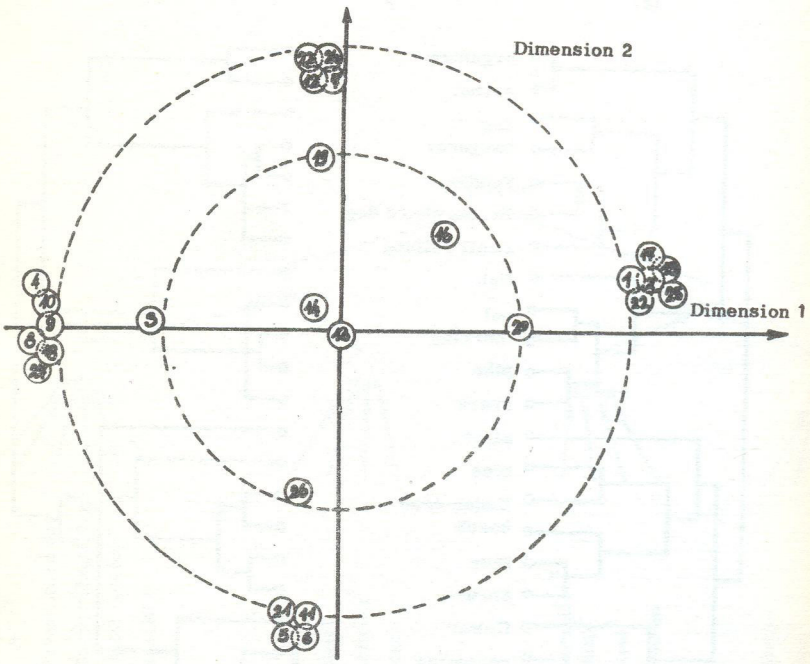
(2) the "data after" show a unique hierarchical structure for all n-algorithms and the rank-correlation coefficient between the observed distances and the ultrametric distances is very high ($r_R = 0,885$). This explains the high dimensionality of these data, because ultrametric distances between n points can only be fitted in a (n-1) - dimensional space.

It is interesting to note that the configuration in Figure 3 approximately fulfills the ultrametric triangle inequality in the concrete clusters. Another interesting point is that the concrete concepts and the second order concepts lie on isosimilarity contours around the highest order superordinate.

The analysis of the free-recall data and the free-card-sorting data in the framework of semi-lattices gives rise to hierarchies, which are nearly identical with the normative "is a" - hierarchy (Fig. 1).

This result shows the influence of the normative hierarchy on coding and retrieving these items.

FIG. 3: TWO-DIMENSIONAL GEOMETRICAL CONFIGURATION OF THE FREE-CARD-SORTING DATA OF THE CONTROL SUBJECTS



Legend

1 pine
2 beech
3 dog
4 pomeranian dog
5 herring
6 pike
7 rose
8 small bulldog
9 badgerer
10 poodle
11 eel
12 tulip
13 organism
14 animal
15 oak
16 plant
17 linden-tree
18 St. Bernard dog
19 flower
20 tree
21 shark
22 spruce
23 crocus
24 carnation
25 fir
26 fish
27 mastiff

REFERENCES

JOHNSON, S.C.: Hierarchical clustering schemes.Psychometrika, 1967, 32, 241 - 245

LINGOES, J.C., ROSKAM, E.E.: A mathematical and empirical study of two multidimensional scaling algorithms. MMPP 71 - I Univ. of Ann. Arbor, 1971

MILLER, G.A.: A psychological method to investigate verbal concepts J. Math.Ps., 1969, 6, 169 - 191

SOKAL, R.R., SNEATH, P.H.A.: Principles of Numerical Taxonomy San Francisco: Freeman, 1963

SZASZ , G.: Introduction to Lattice Theory. New York: Academy Press, 1963

TULVING, E.: Episodic and semantic memory in: E. TULVING/W.DONALDSON (eds.) Organization of Memory New York: Academy Press, 1972

ZIMMER, A.: Probleme bei hierarchischen Clusterverfahren.Vortrag auf der 13. Tagung für experimentelle Psychologie, Graz, 1971

ZIMMER, A.: Die Bildung von Ordnungen im menschlichen Gedächtnis Dissertation, Münster, 1973